Forestry is Applied Mathematics Part 1 Using pi

by **Andrew Weatherall**

"What is pi?" If I am asking this aloud, it must be the second teaching week of the university academic year. I am delivering the first lecture in our 'Measuring Trees and Forests' module to the first year National School of Forestry students studying FdSc Forestry, BSc (Hons) Forest Management and BSc (Hons) Woodland Ecology and Conservation at the University of Cumbria.

"What is pi?" After a moment of stunned silence (does he really expect us to answer him?), the answers begin:

"Approximately three."

"Three point something."

"Twenty two divided by seven."

"Apple."

After a pause, while we all consider the awful inevitability of this joke, one of the quieter ones, who has been waiting for their moment says:

"Three point one four two."

Or even, occasionally, "Three point one four one five nine, erm ... two ... I think." This is followed by appreciative nodded heads and smiles from the other students. I can see them all thinking "That will show him. We, at least one of us, have nailed that answer."

"No." I say. "It is none of those things."

Now they are really baffled.

"Three point something is what pi is equal to." I say "The number is a mathematical constant, but why is it three point something? Where does it come from?"

Now some of them are on the trail.

"It's the perimeter, no ... the circumference of a circle divided by ... the radius?" Starts one.

"No, the diameter ... circumference divided by diameter."

Interrupts another, "That is what pi is."

I smile at them, fire up the PowerPoint and the lecture begins. I do what I assume to be the normal teaching of pi kind of stuff. I talk a bit about Archimedes and then get them to find some circles; water bottles, wall clocks, coffee cups, anything to hand, sometimes even an actual pie from a student lunch box. We write down the circumferences and diameters and calculate pi. We discuss the precision and accuracy of their measurements, take the mean value of pi from their measurements and discuss how that is surprisingly closer to pi than most individual measurements (in all years I have been doing this to date, anyway). So far, so ordinary. At least, I guess this is just like a secondary school maths 'Introduction to pi' lesson?

This is a forestry lecture though. So now I begin to talk about managing woods and forests, how you need to know what you have in order to be able to manage it effectively. How as well as tree species, age, site conditions and management history, you really need to know about the amount of timber/biomass/carbon you have; then, about how all of these can be derived from two measurements of individual trees and, with robust sampling schemes, extrapolated up to forest level. The two measurements are tree diameter and height. I tell them we will talk about height measurement in the next lecture.

Now I focus on tree diameter. We discuss the importance of standard measurement protocols, how everyone needs to measure at the same point on the tree stem, which by convention is 1.3 metres from the ground. I introduce them to their set text (Forestry Commission, 2006), the only book I insist that they buy on the whole course, but warn them that it is a book of pretty scary maths formulae and protocols (from a forestry student perspective) and it is my job to help them interpret it. I do not like insisting on book purchases; however, I tell them that they are allowed to take it into the end of module exam with them, because I am interested in testing their understanding, not just their ability to memorize facts and figures. We discuss how to measure tree stem diameter at 1.3 metres from the ground. They practise finding this point, known as diameter at breast height, quickly, using what I (but no one else really), call the forestry salute.

We dismiss the idea of cutting the tree down to measure the diameter and consider the pros and cons of using large callipers in the woods, and that as tree stems are not perfectly circular, at least two perpendicular measurements with callipers would be required.

Then, just as I am beginning to think that this will be the year that no one says it, one of the students exclaims:

"If only trees were circular, we could measure the circumference, and use pi to estimate the diameter."

"Yes. We could." I say. "And although tree stems are not perfectly circular, they, especially forestry plantation grown trees, are close enough, so this is exactly what we can do."

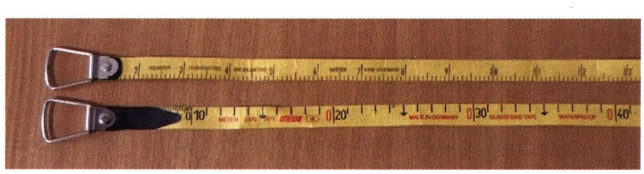
In other modules I like to describe forestry as being "applied biology", or "applied ecology", even "applied geography", but in this 'Measuring Trees and Forests' module, this is the moment when I say:

"Forestry is applied mathematics".

Now I give them each a diameter at breast height, or dbh, tape to look at. Also referred to as a girth tape, you can buy these from reputable forestry equipment suppliers, such as Stanton Hope **www.stantonhope.com/Product/Tools-26-Equipment-181621-Diameter-Tape-Wire-Reinforced**.

The basic ones are less than £10 and these are what we use with our first year students. In my opinion they are the best teaching tool for pi that anyone could ask for. Diameter at breast height tapes have metre and centimetre measurements on one side of the tape which enables you to measure the circumference of the circle and use pi to calculate the approximate diameter. However, the other side of the tape, which, beware, initially looks like it measures inches, actually uses pi to calculate diameter from circumference in advance:

π = Circumference /Diameter.
Therefore, Diameter = Circumference / π.



Thus, if a tree has a circumference of 31.42 cm recorded on the first side of the tape, flipping the tape over will reveal that the diameter on the other side is 10.00 cm.

The final step in the lecture is, of course, to take them outside. I did not become a forestry lecturer to spend all my time indoors and our students did not choose our courses to sit in lecture rooms, listening, when they could be doing. We are fortunate to be based at our Ambleside Campus, in the heart of the Lake District National Park. It is our laboratory and we have plenty of trees to practise on.

I think this is a perfect application of pi, an excellent way to reinforce learning, but I am a forestry lecturer, you would expect me to think that. The question is, would it help maths teachers to use diameter at breast height tapes to help secondary school pupils realize that maths is not just classroom theories, but underpins real world working practices?

Reference

Forestry Commission. 2006. *Forest Mensuration: A Handbook for Practitioners.* Forestry Commission, Edinburgh.

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